

Hammond (Wm A.)

THE
PHYSIOLOGY AND PATHOLOGY
OF THE
CEREBELLUM.

BY ✓

WILLIAM A. HAMMOND, M. D.,

PROFESSOR OF DISEASES OF THE MIND AND NERVOUS SYSTEM, AND OF CLINICAL MEDICINE,
IN THE BELLEVUE HOSPITAL MEDICAL COLLEGE; VICE-PRESIDENT OF THE ACADEMY
OF THE MEDICAL SCIENCES; OF THE NATIONAL INSTITUTE OF LETTERS,
ARTS, AND SCIENCES, ETC., ETC., ETC.

[FROM THE QUARTERLY JOURNAL OF PSYCHOLOGICAL MEDICINE AND
MEDICAL JURISPRUDENCE FOR APRIL, 1869.]

NEW YORK:
D. APPLETON & COMPANY,

90, 92 & 94 GRAND STREET.

1869.

L. W. SCHMIDT, 24 Barclay Street, New York.

THE
PHYSIOLOGY AND PATHOLOGY
OF THE
CEREBELLUM.

BY
WILLIAM A. HAMMOND, M. D.,
PROFESSOR OF DISEASES OF THE MIND AND NERVOUS SYSTEM, AND OF CLINICAL MEDICINE,
IN THE BELLEVUE HOSPITAL MEDICAL COLLEGE; VICE-PRESIDENT OF THE ACADEMY
OF THE MEDICAL SCIENCES; OF THE NATIONAL INSTITUTE OF LETTERS,
ARTS, AND SCIENCES, ETC., ETC., ETC.

[FROM THE QUARTERLY JOURNAL OF PSYCHOLOGICAL MEDICINE AND
MEDICAL JURISPRUDENCE FOR APRIL, 1869.]

NEW YORK:
D. APPLETON & COMPANY,
90, 92 & 94 GRAND STREET.
1869.

THE
PHYSIOLOGY AND PATHOLOGY
OF THE
CEREBELLUM.

(Read before the New York County Medical Society, January 4, 1869.)

THE anatomical relations of the cerebellum are so distinct as regards size, position, and structure, that physiologists, ever since the development of their science, have sought with great assiduity to discover its functions. First one view and then another has been brought forward and urged by argument and by appeals to pathology and experiment, but each has in its turn lost ground with time, until now it is certain that no one theory obtains undivided acceptance, if it even commands a majority in its favor. It is, at first sight, difficult to account for this skepticism. The organ in question is one which can readily be submitted in living animals to observation and experimental research; it is in great part devoid of sensibility, it may be pricked and torn and electrized and cauterized with impunity, and in some animals may even be al-

together removed, and life still remain for a long time. It might, therefore, be fairly supposed that these circumstances would have led to some definite results. So far, however, from this being the case, they have tended to increase the obscurity of the subject, for it is very certain that the functions of an organ, which can be mutilated or entirely ablated without the production of notable and uniform consequences, cannot be very pronounced in their character, even though indispensable to the permanent well-being of the animal.

Before the time of Willis the functions of the cerebellum were confounded with those of the cerebrum. This author is declared by Vulpian to be the founder of cerebellar physiology, but his works contain little more than fanciful hypotheses unsustained by facts. He regarded the cerebellum as presiding over the involuntary motions, as being the organ of music, and as a generator, by its cortical substance, of the animal spirits.

Foville,¹ basing his ideas on the anatomical arrangement and the relations of the cerebellum to the spinal cord, regards it as the centre of common sensation. This view is likewise entertained by Pinel, Grandchamp, and Dugès. Experimental physiology and pathology do not, however, support the hypothesis, for it is found that injury, disease, or even complete removal of the organ in question, produces no notable diminution of sensibility in any part of the body.

Passing over several other theories which have been

¹ *Traité Complet de l'Anatomie, de la Physiologie, et de la Pathologie du Système Nerveux.* Paris, 1844.

advanced, relative to the functions of the cerebellum, there are two which I propose to consider somewhat at length. These are, first, that it is the originator and controller of the sexual appetite, and, second, that it coördinates the various muscular actions of the body.

The first theory originated with Gall, and, though it met with great opposition when it was promulgated, and though it is still vigorously combated, there is a good deal of evidence in its favor. Doubtless much of the odium in which it is held is due to the fact that numerous ignorant pretenders to science have embraced it. This, however, should not prevent us investigating its pretensions with fairness.

Numerous cases of injury and disease of the cerebellum attended with derangement of the generative function are referred to by Combe¹ and other writers. Larrey,² in an elaborate paper, sustains Gall's theory, and adduces several cases in its support. He alleges that acute inflammation of the cerebellum is always accompanied with an exalted state of the animal and organic sensibility, without there being any disturbance of the intellectual functions. If the injury or disease be located in only one of the lobes, the increase of sensibility will be found on the same side of the body, and will be attended in various gradations by acute pain in the occipital region, horripilations, gradual or convulsive contractions of the muscles of the face and of the upper and lower extremities of the affected side, together with painful formication in the fingers and toes. Should paralysis supervene, it is always, he as-

¹ A System of Phrenology. Boston, 1834, p. 110.

² Observations on Wounds, etc. Translated from the French by E. F. Rivinus, M. D. Philadelphia, 1832, p. 179.

serts, confined to the muscles on that side of the body corresponding to the diseased or injured side of the cerebellum.

In case the patient recover, he will, according to Larrey, be subjected to some remarkable infirmities, such as a feeling of excessive tenderness in the neck and occipital region, and a decided asthenia of the genital organs, combined with atrophy of the testicle of the side which corresponds to the diseased lobe of the cerebellum, or of both, if the whole of this part of the encephalon be affected.

In support of his remarks, Larrey cites the case of a young soldier, who, in Egypt, was struck on the back of the head by a large splinter of wood. Inflammation, supposed to be located in the cerebellum, supervened. He eventually so far recovered as to be sent to France. Several years elapsed before he again came under Larrey's notice. It was then found that his genital organs were reduced to the size of those of an infant a few months old; the power of erection was lost, and sexual desire had disappeared.

In another case, a soldier was struck by the ball of a blunderbuss, which, grazing the occipital protuberance, tore away the extensor muscles of the head in its passage from one side to the other. "The patient immediately felt a violent pain in the occiput and a sense of weight in the whole head, together with numbness of the lower extremities. His vision and hearing were so much impaired that he could hardly discern any large objects or understand the most piercing sounds. His testicles became reduced and wasted away, and his penis diminished in the same proportion, and lost the power of erection."

The third case was that of a man who had received a sabre-cut through the occipital bone and dura mater, so that the right lobe of the cerebellum could be readily seen and touched. When the finger was pressed upon it, ever so gently, vertigo, syncope, and convulsions were induced, but no pain was experienced. After the first few days the patient lost the faculties of vision and hearing on the right or affected side. At the same time there was violent pain along the course of the spine, and a kind of formication in the testicles, the size of which rapidly diminished, so that in less than a fortnight they were reduced to the size of small beans. The sexual passion became utterly extinguished.

In the fourth case, the patient was struck on the back of the head; among other consequences, the right testicle became atrophied, and the power of erection lost.

In the fifth case, in consequence of a blow on the head with a piece of wood, an abscess of the right lobe of the cerebellum was produced, of which, in about three months, the patient died. The *post-mortem* examination showed entire disorganization of the right lobe, and marked atrophy of the testicle of the affected side.

In the sixth case, disease of the cerebellum was the consequence of erysipelas. The patient lived two months subsequently. The *post-mortem* examination revealed the existence of an abscess which had entirely taken the place of the left lobe of the cerebellum. The scrotum and penis were so much reduced from their original size as to be in the second stage of atrophy.

Two other cases are cited, in which disease of the testicles led to supposed atrophy of the cerebellum.

It is worth noticing that in no one of these cases was any difficulty in coördinating the muscles perceived.

Without citing other cases similar to those of Larrey, and which are familiar to the profession, I desire to refer to three remarkable instances, the details of which are given by Dr. John D. Fisher,¹ of Boston, but which appear to have escaped the notice of recent writers :

The first was that of a man aged forty-five, who was seen soon after his death, which took place from pneumonia. The penis was small; the glans had evidently seldom, if ever, been uncovered. When exposed, it was small, pale, and pointed; all the parts of the organ resembled those of a boy not yet arrived at the age of puberty. The scrotum was soft and flabby, and was empty. No testicles were anywhere to be found.

The head was large, measuring 22 inches in circumference. The brain was healthy and very large, weighing 51½ ounces. The relative proportion of the cerebellum to the cerebrum was much reduced, for, while the latter weighed 47 ounces, the former weighed but 4½ ounces. According to Meckel and others, the average weight of the cerebrum and cerebellum, united, is 48 ounces—and the weight of the cerebellum to that of the cerebrum is as 1 to 7, or 1 to 8. In this case, the cerebellum measured, in its transverse diameter, 4 inches; in its antero-posterior diameter, 2½ inches; and in thickness, 1½ inch; ordinarily, it measures, transversely, 4 inches; antero-posteriorly, 2½ inches, and perpendicularly, 2½ inches. It was, therefore, one-

¹ Contributions illustrative of the Functions of the Cerebellum. American Journal of the Medical Sciences, February, 1839.

third less in size and weight than is ordinarily the case in an adult male, and was the exact weight of that of a female child six years old, whose body was examined at the same time.

The history of the patient is very interesting. The deficiency of testicles was discovered by Dr. Warren. His voice was like that of a woman; he had no beard, he never exhibited any amorous propensities, or desire for female society—as his mother expressed it, he was a virgin in feeling and conduct to the day of his death.

The second case was that of a man aged forty-one, who, while a passenger in a railway train, was injured by a collision, so that the back part of his neck was struck violently against the window-frame of the car. The blow was so severe, that he remained for some time in a state of insensibility; at first, it was thought that his skull was fractured, or his neck dislocated. He, however, regained his intelligence, and was conveyed to his residence. On visiting him an hour after the accident, Dr. Fisher found him suffering great pain in the occipital portion of the head and upper part of the neck. He was lying on his back, and was unable to rotate his head or move from a horizontal position. Every attempt to do so was attended with excruciating pain. The muscles of the neck and integuments were swollen, but there were no indications of fracture of the cranium, or of fracture or dislocation of the vertebræ.

On the second day after the accident, he complained of numbness of the right arm, and of a difficulty in passing his urine. Another interesting symptom occurred after two weeks when he had left his bed. He lost the power of estimating distances; near objects appeared to be far off, and to be far below him. The

street seemed to be of interminable length, and he felt as if he were very much taller than the persons with whom he conversed. Between the fourth and fifth week after his accident, he made the discovery that he had lost the desire and physical power for sexual intercourse; the ordinary excitations failed altogether in causing any amorous feeling, and this condition, he was of opinion, had existed since the reception of the injury. In the course of four months, the bladder recovered its contractile power, but the arm remained numb for several months longer. The generative function continued dormant for two years, and six months later was only partially active.

The third case is related by Dr. Whittemore. An old man, aged seventy-three, had been married forty years, and had had eleven children. Soon after marriage, he began to complain of dizziness and noises in the head, to which he was more or less subject till his death. Four years before this event, he experienced, on rising from bed, for three or four mornings in succession, excruciating pain in the head, which was followed by a sensation as if something had given way in the left side of the head with an audible crack, which led him to inquire if the bystanders had not heard the sound, and he was astonished to find they had not. After this he became partially deaf in the left ear, and the dizziness increased. During these dizzy turns, he was obliged to catch hold of the nearest object to keep from falling, and at such times every thing seemed to be whirling about like wheels, with a motion always from right to left. Two years subsequently, he had an attack of hemiplegia, and subsequently experienced two other attacks, all slight. After the occurrence of these, he had a morbid salacity, which continued with

little intermission till about three months before his death, when it began to subside, so that the desire became imperious but once or twice during the night. There was, however, no ability to gratify it, owing to imperfect erection; and for a year there had been no seminal emission. During this last period, he had been gradually getting worse, and his mind had lost most of its power. A few weeks before his death, he had two epileptic attacks.

On the day after his death his head was examined. The dura mater was adherent to the skull, the arachnoid was thickened, there was a large quantity of serous fluid in the pia mater, and the arteries were undergoing ossification; otherwise, the brain was healthy, except as regarded the cerebellum. The right lobe of this organ was healthy; the left lobe was one-fifth smaller, and was found to have lost the greater part of its substance owing to the formation of a cavity in its tissue. The sides of the cavity were in contact, but it had probably contained serum, which had escaped when it was laid open. A coagulum, the size of a duck-shot, was found in the left crus, a small portion of which was destroyed by disease. As remarked by the author, we have in this case a somewhat remarkable proof of a relation existing between the cerebellum and the instinct of reproduction. The revival of the instinct and powers of propagation, which had been extinguished for years, taking place on the accession of a disease of the cerebellum, and continuing active till the organ began to lose its firmness of texture, and to undergo disorganization, is strong confirmation of the evidence furnished by the two preceding cases, that this part of the brain is the source and centre of the instinct.

The noticeable features of these cases, besides the derangement of the sexual appetite, are the entire absence, in all, of any symptoms indicating a loss of the power of coördination, and the presence of vertigo in the third case. (This, it will be recollected, was the only one in which either of the crura cerebelli were affected.) It will be noted, also, that the hemiplegia occurred upon the side of the body opposite to that of the disease in the cerebellum.

'Georget,' whose works upon the brain and nervous system are so important, and who has so carefully studied the manifestations of the mind in health and disease, writes as follows relative to the point under consideration :

"Physicians have observed certain phenomena of the generative organs in cerebral affections. Thus, erection has been noticed by Bichat as a symptom of such disorders. It is not rare in ataxia [Georget does not here refer to locomotor ataxia, as now recognized, but to an affection described by Pinel, characterized by loss of strength and general enfeeblement of the power of sensation and motion]. M. Serres has seen it in two cases of disease of the cerebellum, of which one consisted of an extravasation of blood, and the other of an inflammation. It is well known that individuals who are hung frequently exhibit this phenomenon, and that others have been so depraved as to cause themselves to be suspended by the neck in order to procure the power of satisfying their venereal desires.

"M. Gall placed the seat of physical love in the cerebellum. Of all his other phrenological doctrines, this is the one in regard to which he has brought for-

¹ De la Physiologie du Système Nerveux et spécialement du Cerveau, etc. Paris, 1821, vol. ii., p. 163.

ward the greatest amount of proof. The cases of M. Serres are here of some weight. M. Larrey cites the case of a young soldier who had received a sabre-cut on the back of the neck, and who never thereafter experienced any venereal excitement. Hippocrates assures us that the Scythians rendered themselves impotent by dividing the veins behind the ears. This tradition, although not founded on fact, indicates, nevertheless, that they had recognized a connection between the nape of the neck and the genital organs. Ferrand, in his treatise *De la maladie d'amour, ou mélancolie érotique*, assures us that physicians have obtained benefit by the application of leeches to the nape of the neck of patients affected with this disease. I have myself seen, at the Salpêtrière, a woman of ardent temperament, whose only mental derangement consisted in imperious venereal desires. Before her entrance into the hospital she had frequently had sexual intercourse ten or fifteen times a day. During her stay, she was very often seized with a violent pain in the nape of the neck, and at the same time experienced the most irresistible sexual desires, which she satisfied by masturbation ten or fifteen times a day. These acts did not appear to injure her, and soon caused the pain in the occiput to disappear."

Many other cases, similar to those I have referred to, might be readily adduced, were it necessary to do so. The fact may be regarded as unquestionable, that lesions of the cerebellum do occasionally give rise to abnormal sexual manifestations, either of increase or diminution. What the physiological and pathological importance of this point may be, I propose next to inquire.

Researches into the comparative anatomy of the

subject go to disprove Gall's theory. The *Amphioxus lanceolatus* is a vertebrate, the lowest of the fishes, and is devoid of a cerebellum. The organ, therefore, is not necessary for the performance of the reproductive functions. No observations have been made, so far as I am aware, relative to the strength of the sexual passion in this singular animal.

Passing upward a little, we come to the lamprey, in which, as likewise in the sturgeon, polypterus, and lepidosiren, the cerebellum consists of a simple commissural bridge or fold. In these fish the generative organs are extraordinarily large, and in the lamprey the sexual instinct is unusually developed, for, during the act of copulation, they are stated by Owen¹—and as I have myself often observed—to entwine or wreath themselves about each other, and thus mutually aid in the expulsion of their respective generative products. So absorbed do they become in their passion, that they permit themselves to be taken out of the water and replaced without interrupting the act. The cerebellum is smaller in the lamprey than in any other fish.

In the shark, on the contrary, it is largest, but it is well known that the sexual passion is very feeble in this animal.

Among reptiles, the frog has the smallest cerebellum, and yet this creature is remarkable for its strong sexual manifestations, which are so powerful that it will continue to embrace the female even after its fore-feet have been amputated. In fact, as I have ascertained by experiment, the removal of the cerebellum in this animal does not destroy the sexual proclivity.

¹ Anatomy of the Vertebrates. Vol. i. Fishes and Reptiles. London, 1866, p. 287.

In birds, the cerebellum is large and very much more developed than in the fishes or reptiles. It is marked by circumvolutions or transverse lamellæ, which vary in number, in different birds, according to the greater or less size of the cerebellum. According to Leuret,¹ the number of these lamellæ is never less than ten nor more than twenty.

Now, as regards the generative function, it will not, I think, be found that there is any direct accordance between its power and the number of the cerebellar lamellæ. In the chicken they number fourteen, and in the goose, sixteen. Yet the former is undoubtedly more salacious than the latter. In the pigeon and others of the dove family, they number sixteen, and in the magpie, twenty; but the former are remarkable for their excessive amorous passion, while in the latter it is by no means a noticeable characteristic.

Among mammals the cerebellum reaches its highest state of development, and in man its utmost degree of size and complexity of structure. But we find no correspondence between this organ and the sexual appetite such as Gall has attempted to establish. In the cat, for instance, the cerebellum is for a mammal slightly developed, the lateral lobes being very small, but no one will contend for the existence of slight sexual passion in this animal. In regard to this point, Dr. Carpenter says:

“A friend who kept some kangaroos in his garden informed the author that they were the most salacious animals he ever saw—yet their cerebellum is one of the smallest to be found in the class (mammalia).

¹ Anatomie Comparée du Système Nerveux. Paris, 1839-1857, t. i., p. 281.

Every one knows, again, the salacity of monkeys, there are many which are excited to violent demonstrations by the sight even of a human female, and there are few which do not practise masturbation when kept in solitary confinement; yet in them the cerebellum is much smaller than in man, in whom the sexual impulse is much less violent."

Budge¹ made the discovery that in females irritation of the cerebellum caused movements in the cornua of the uterus and tubes. He also found that a like exciting cause produced, in the male, movements of the testicles and vasa deferentia. Thus he says:

"By a lucky coincidence I made the gratifying observation that in an old cat whose testicles lay in the abdominal cavity, these organs immediately after death moved whenever the cerebellum was irritated with the scalpel or with caustic potash. The effect was such that, whenever the right lobe of the cerebellum and the right half of the vermiform process were irritated, movement of the left testis ensued, and the reverse. Mere superficial irritation sufficed to produce this result. The movement of the testicles soon became so palpable in this animal that there could be no doubt as to its reality. I hastened to open the entire skull and the abdominal cavity, and found the testicles lying perfectly still, without any trace of movement. On irritating one side of the cerebellum, the testicle of the opposite side swelled, quitted its position, and rose up so as to form a right angle with the spermatic cord, one side of the angle being directed forward. If I desisted from the irritation, the testicle returned to its position, and the movement was renewed on renewing the irri-

tation. The experiment was repeated during half an hour, with unvarying results. After the first irritation, not three seconds elapsed before the movement followed; subsequently, the interval between the irritation and the effect was prolonged. The movement only lasted a short time, and was diminished more and more. Alternately with the cerebellum, I irritated the cerebrum, the corpora quadrigemina, the thalami optici, the corpora striata, but I have never seen the slightest movement result from the irritation of these parts."

Valentine confirms Budge's observations, but Volkmann has never been able to do so, and Müller discredits them altogether.

I have endeavored to satisfy myself in regard to these points, by repeating Budge's experiments. In one instance, in which a cat was used, decided movements of the testicles were induced by irritating the cerebellum with a scalpel, or with the continuous galvanic current, applied through two needles. The irritation of the left lobe produced movements in the right testicle, and *vice versa*. When the current was passed through both lobes, both testicles were moved, and the penis was also brought into a state of erection. I was at first disposed to attach considerable importance to these facts, as indicating a very close relation between the cerebellum and the generative organs; but, by further observation, I found that irritation of the medulla oblongata and of the cerebrum produced like movements in both testicles and the penis. I also found that irritation of the cerebellum, in either way I have specified, caused movements of the intestines, of the abdominal muscles and of the muscles of the thigh and back. My experiments were performed upon three cats just killed. I am hence disposed to attach less importance to

Budge's observations than does Romberg,¹ who quotes them with evident approbation. They are, nevertheless, interesting, as showing that, though the connection between the cerebellum and the sexual organs is not exclusive, there is a relation, in which, however, other parts of the body participate, and which, likewise, exists with other parts of the brain.

Coming now to man, we find numerous facts which are altogether irreconcilable with Gall's hypothesis. We have seen that there are many cases of injury and disease of the cerebellum on record, which tend to show that there is some connection between this organ and the sexual passion. Observation, however, shows us that, as in the lower animals, other parts of the cerebro-spinal axis participate in this connection, and that the integrity of the cerebellum is not at all essential to the existence of strong venereal propensities.

In the first place, blows upon the back of the neck are more apt to injure the spinal cord or medulla oblongata than the cerebellum. The same is true of hanging—so that the cases of these kinds, brought forward in support of Gall's theory, prove at least as much for these organs as they do for the cerebellum.

Burdach² collected one hundred and seventy-eight cases of injury and disease of the cerebellum, of which but ten exhibited any aberration of the sexual function.

In his classical treatise, Ollivier³ (d'Angers) refers to fifteen cases (thirteen occurring in his own expe-

¹ A Manual of the Nervous Diseases of Man. Sydenham Society Translation, vol. ii., p. 33.

² Vom Baue und Leben des Gehirns. Leipsic, 1819-1826; vol. iii., p. 423.

³ Traité des Maladies de la Moelle Épinrière. 3d edition, Paris, 1837; t., i. pp. 316-367.

rience) of lesions attended with compression of the spinal cord in the cervical region, in eight of which there was erection of the penis. In thirteen cases of similar lesions in the dorso-lumbar region, erection occurred in three.

Andral¹ declares that, in thirty-six cases of disease of the cerebellum, permanent erection of the penis was present in one only; and, in this, the tubercular mass constituting the disease pressed upon the superior part of the spinal cord.

A preparation in the Anatomical Museum, at Bonn, is, as Müller² states, unfavorable to Gall's opinion. It is the cerebellum of a man, in whom half the organ was found atrophied. Death had been caused by an inflammatory disease. But the sexual passion had been rather strong than weak. The man was married, and the father of several children.

But the most remarkable case is one reported by M. Combette,³ whose paper is entitled "Case of a young girl who died in her eleventh year, in whom there was complete absence of the cerebellum of the posterior peduncles, and of the annular protuberance." I shall refer to this case more at length when I come to discuss another theory of cerebellar function. At present I will only state that the girl's name was Alexandrine Labrosse, and that Magendie satisfied himself by careful examination that the defect was congenital. She entered the Hôpital Saint Antoine, where she died. M. Combette asserts that he had obtained the certain knowledge that this girl practised masturbation.

¹ Clinique Medical, t. v., 2d edition, p. 735.

² Elements of Physiology, translated by Baly, vol. i., p. 832; quoted from Wagner in Nova Act., Nat. Cur., xiv., p. 111.

³ Journal de Physiologie Expérimentale et Pathologique. Par. F. Magendie, t. xi., Paris, 1831, p. 27, *et seq.*

I have witnessed three cases of injury of the spinal cord, in which there were painful and frequent erections, and two in which the faculty seemed to be altogether lost. The usual influence of disease of the cord, such as congestion, meningitis, and myelitis, is in the early stages to produce frequent erections; later in the course of these affections, the symptom disappears. In white softening of the cord, the power of erection is lost very soon.

In two cases of general paralysis under my care, in which there was no reason to suspect any cerebellar lesion, erections, accompanied with strong sexual desires, occurred among the first symptoms. As the disease advanced toward a fatal termination, these symptoms became absent.

Gall asserts that the loss of the testicles causes atrophy of the cerebellum. This opinion has not been sustained. Leuret¹ made many investigations relative to the point, and found that in geldings the average weight of the cerebellum was 70 grammes; in stallions, 61, and in mares, 61. The proportionate weight of the cerebellum to the cerebrum was in geldings as 1 to 5.97; in mares, as 1 to 6.59, and in stallions as 1 to 7.07. So far from the cerebellum decreasing from castration, it was found that the cerebrum lost weight from this cause.

Now, if the cerebellum were the sole or even the chief originator of the sexual impulse, it ought, judging by analogy, to have decreased in size after castration. Instances of the dependence of structural integrity upon the excitation due to functional activity are so frequent, that it is scarcely necessary to cite them.

The other hypothesis relative to the function of the

¹ Anatomie Comparée du Système Nerveux, t. i., p. 425, *et seq.*

cerebellum is that which ascribes to it the power of coördinating the various muscles of the body so as to make them act in harmony, and to obey exactly the mandates of the will.

Although Rolando,¹ in 1809, asserted, from numerous experiments, that the cerebellum is the source and origin of all muscular movements, the theory which regards it as especially the coördinator originated with Flourens in 1822 and 1823, and was published by him in papers read in those years before the French Academy. My account of it is obtained from the second edition of his work on the nervous system,² published in 1842.

Flourens performed his experiments on birds and mammals: among the former class, upon the pigeon, turkey, swallow, sparrow, owl, and duck; among the latter, on the dormouse, cat, mole, and dog. His method was to cut away the organ in successive slices. In all his experiments, disorder of movement was produced, and this disorder was the more marked, according to the extent of the mutilation—till, at last, the animal fell, unable to move at all. Flourens states, in regard to all of them, that their motions were like those produced by drunkenness. He shows, likewise, that the cerebellum is insensible; that its injury or removal does not interfere with the senses of sight or hearing, and that volition and memory are not abolished. A blow aimed at an animal thus injured is seen, and the effort is made to avoid it, but the power to do so is lost. Injury of one side of the cerebellum affects the muscles of the opposite side of the body.

¹ Saggio sopra la vera struttura del cervello, etc. Sassari, 1809.

² Recherches Expérimentales sur les Propriétés et les Fonctions du Système Nerveux. Second edition, Paris, 1842.

Harting¹ repeated Flourens's experiments, and with analogous results. He found that the cerebellum was devoid of sensibility; that convulsions were not induced by its irritation; that the senses remained in a state of integrity, and that no other function appeared to be affected except that which relates to order in the movements. He also noticed that, in those cases where the mutilation had been partial only, the power of regulating the motions was soon regained.

Bouillaud, Longet, and many others have obtained results similar to those of Flourens, and have drawn like conclusions from them.

But, very soon after the publication of Flourens's *Memoirs*, Magendie went over the ground and declined to accept his hypothesis. He states² that hedge-hogs and Guinea-pigs, from which he had removed not only the cerebellum, but the cerebrum also, rubbed their noses with their fore-legs when a flask of vinegar was applied.

Now, one such instance, well authenticated, is sufficient to overturn Flourens's hypothesis; for, if one animal can coördinate its movements when deprived of its cerebellum, then that organ is not absolutely essential to such coördination. Nevertheless, Flourens's views upon the subject have been largely accepted, and probably no other theory of cerebellar function can count as many adherents.

The arguments which may be brought against it are, however, so forcible, and experiments performed upon animals of different classes are so strikingly against it, that I am forced to regard his doctrine as un-

¹ *Experimenta quædam de affectibus læsionum in partibus encephale*, 1826.

² *Précis Élémentaire de Physiologie*. Quatrième édition. Paris, 1836, t. i., p. 408.

tenable. In addition, the records of pathology furnish evidence which is absolutely fatal to its pretensions :

First. The consequences of removal of the cerebellum, if the animal survives the immediate effects of the operation, are not enduring.

Flourens himself found that there was greater weakness and hesitation of motion immediately after the operation than at a subsequent period. Harting found that the full power eventually returned.

Wagner,¹ in 1858, says of animals, from which the cerebellum has been removed :

“The most prominent feature of these phenomena is, that they disappear completely, or at least in great part, at the end of half an hour, or an hour, if the animal is allowed to rest in a comfortable position. When the animals survive the operation, and after the wound is healed, they continue to walk, though in a somewhat uncertain manner, with the feet wide apart, notwithstanding that a considerable portion of the cerebellum may have been removed. In the generality of cases all the symptoms disappear in a few days, and the animals recover the faculty of walking, flying, etc. It is, therefore, very probable that the phenomena, which are manifested immediately after the operation, are due to slight injuries or shocks to the deeper parts, such as the peduncles of the cerebellum or the medulla oblongata, and that momentary troubles are consequently produced in the muscles corresponding to these parts.”

Dalton's² experiments are to the same effect. He says :

¹ Nachrichten von der Universität und der Königl. Gesellschaft der Wissenschaften zu Göttingen. Also Journal de la Physiologie de l'Homme et des Animaux, Avril, 1861.

² American Journal of the Medical Sciences, January, 1861, p. 83. Also Treatise on Human Physiology, 4th edition, 1867, p. 416.

"In the month of January, 1859, I removed from a young but well-grown male pigeon, while under the influence of ether, the upper and middle portions of the cerebellum, constituting about two-thirds of its entire mass. Immediately afterward the pigeon showed all the usual effects of this operation in a very marked degree. He was incapable of walking, of flying, or even of standing still, but struggled and sprawled about exactly as other pigeons had done when subjected to a similar mutilation. He was used very successfully to illustrate the effects of this operation before the medical class.

"This pigeon, however, contrary to my expectation, survived, and in the course of a few days it was evident he was recovering the control of his limbs. This recovery continued to go on at the same time, with the general reestablishment of the animal's health, and at the end of five or six days he was again very nearly capable of executing all his natural motions—his appetite was also restored, and he ate and drank freely, as before the operation."

This pigeon lived for sixteen days, at the end of which time he was purposely killed. During his life, after the operation, he got along very well, eating, flying, walking, and even fighting the other pigeons which attempted to take his food.

Examination showed that about two-thirds of the cerebellum had been removed. No attempt at reproduction had been made.

I have performed several similar experiments to the same effect. On one occasion I removed somewhat more than two-thirds of the cerebellum from a crow. The animal was at first affected in the characteristic manner, but gradually it regained its normal condition,

and was able to fly, walk, hop, and to alight with great exactness. It lived for three months after the operation, and was then accidentally killed.

In another experiment, upon a chicken-cock, I removed more than half of the cerebellum. For a few hours the animal was unable to stand, and kept continually moving its head in a gyratory manner, as if affected with vertigo. Gradually these phenomena disappeared, and in a few days the animal was not to be distinguished in his movements from other roosters. Several months afterward, he was killed, and, upon examination, it was found that the remaining portion of the cerebellum down to the peduncles had disappeared. It was a noticeable fact that the amorous propensities of this bird were not abolished by the operation, but that he still continued to perform his marital duties.

2. *The entire removal of the cerebellum from some animals does not apparently interfere in the slightest degree, even for a moment, with the regularity and order of their movements.*

I have extirpated the cerebellum from the gold-fish (*Carp*o), the sun-fish (*Pomotis*), the gar (*Lepidosteus*), the trout (*Salmo*), the perch (*Perca*), and other genera of fish, without observing the least irregularity of movement. The animals swam and balanced themselves in the water, as well without as with a cerebellum.

From frogs I have removed it very many times, without in the slightest degree, so far as I could perceive, impairing their powers of motion or of coördination. I have also frequently extirpated it from snakes, lizards, and turtles, with like results.

I know it may be alleged that the movements of fish and reptiles are very simple, and that therefore

they have no use for a cerebellum. But this argument will not stand. They do have a cerebellum, and, in order to perform their various movements, they must coördinate. Neither are their movements always so very simple. The fish, in balancing itself in the water, in avoiding obstacles, and in seizing its food, often exercises a great deal of coördinating power. The lizard is remarkable for its agility, and for the accuracy of its movements, in catching its prey.

In relation to serpents, their motions are too often regarded as consisting of simple lateral vibrations of their bodies. But in reality their movements are very complex. Owen¹ calls attention to this general error, and says:

“Serpents climb trees by the same mechanism and actions as in the first kind of locomotion; the edges of the erected scutes laying hold of the bark in succession as the body glides spirally up the bough. The tail has a prehensile faculty, especially exercised by the great constrictors while waiting for their prey. . . .

“Serpents are too commonly looked down upon as animals degraded from a higher type, but their whole organization, and especially their bony structure, demonstrates that their parts are as exquisitely adapted to the form of their whole and to their habits and sphere of life as any animal which we call superior to them. It is true that the serpent has no limbs, yet it can outclimb the monkey, outswim the fish, outleap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird upon the wing; all these creatures have been observed to fall its prey. The serpent has neither

¹ On the Anatomy of the Vertebrates, vol. i., ‘Fishes and Reptiles,’ London, 1866, p. 261.

hands nor talons, yet it can outwrestle the athlete, and crush the tiger in the embrace of its ponderous overlapping folds. Instead of licking up its food as it glides along, the serpent uplifts its crushed prey and presents it grasped in the death-coil as in a hand to its slimy, gaping mouth."

It is true that frogs in jumping and swimming simply flex and extend their legs, but they must, nevertheless, flex and extend them synchronously or dis-synchronously according as they desire to move directly forward or obliquely, and therefore must coördinate. Besides, many of their motions are more complex, such as turning themselves on their bellies after being placed on their backs, applying their feet to the exact seat of an irritation in order to remove it, etc. In the tree-frog (*Hyla*)—from which I have also removed the cerebellum without deranging the motional powers of the animal—the movements are such as to require still more coördinating power. In turtles, the number and variety of the movements are extensive, and the ability to coördinate correspondingly great. Yet in these animals removal of the cerebellum does not appear to interfere in the least with the integrity and harmony of the muscular actions.

3. *The disorder of movements which results in birds and mammals immediately after injury of the cerebellum is not due to any loss of coördinating power, but is the result of vertigo.*

The careful examination of the phenomena exhibited by a pigeon after ablation of the cerebellum shows that it is suffering from a vertiginous sensation. Even when placed on its breast and allowed to remain at rest, there is a trembling and swaying of the body such as is produced by alcoholic intoxication. Now, under

such circumstances, there are no muscular actions to coördinate, and yet the animal makes efforts with its wings to preserve its equilibrium. When it attempts to walk, it staggers and instantly endeavors to maintain its balance. Flourens always speaks of this phenomenon as being like that exhibited by a drunken animal—but fails to distinguish it from that which would be exhibited if the coördinating power were lost. I have several times rendered cats, rabbits, and Guinea-pigs drunk with whiskey. Their movements are exactly like those which result in other animals after injury of the cerebellum. My friend Professor A. Flint, Jr., informs me that he has recently made pigeons drunk, and that they act like those which have suffered injury of the cerebellum. I have recently performed similar experiments upon several pigeons. In every case the appearance and actions of the animal were not to be distinguished from those which occur after removal of the cerebellum. There were the same sprawling of the wings, the same hesitating and staggering gait, the same uncertainty of flight, the same ineffectual efforts to avoid a blow, and the same gyratory motion of the head and trembling of the body. I do not believe the most experienced experimental physiologist could distinguish between two pigeons, one of which was drunk and the other suffering from an injury of the cerebellum. I propose to show the difference between the phenomena of vertigo and incoördination under another division of the subject.

4. *The phenomena of cerebellar disease or injury, as exhibited in man, are not such as show any derangement of the coördinating power.*

Reference has already been made to the case of Alexandrine Labrosse, reported by Combette. It is stated

that when she entered the hospital she had but little intelligence, appeared indifferent to what was going on around her, though she evinced gratitude to those who nursed her. When she was spoken to, she answered with hesitation and difficulty. Her limbs, although weak, were yet strong enough to allow of her walking, though she often fell. She possessed all her senses. She ate moderately, and all her functions of nutrition were well performed.

A year afterward, she had been constantly in bed for three months, her face was pale, and her countenance exhibited an appearance of stupor and of a deteriorated constitution. She remained constantly on her back, with her head inclined to the left. She could hardly move her limbs, but the sensibility was not diminished. She used her hands readily—and when addressed only answered yes or no, but always correctly. She died on the 21st of March, 1831, fifteen months after her admission to the hospital, and at the age of eleven years.

Upon *post-mortem* examination the cerebellum was found to be entirely absent. In its place there was a cellular gelatiniform membrane, semicircular in shape, and about eighteen or twenty lines in length. There was no *pons variolii*.

As M. Combette remarks, Alexandrine Labrosse had been able to walk for several years, although always in an uncertain manner. Gradually her legs lost their strength, and she became paraplegic. Besides, she preserved the use of her upper extremities up to the last. It is very evident, therefore, that the weakness of her legs was due to paralysis—for, had it been the result of incoördination, the arms must necessarily have participated. In conclusion, M. Combette says, after

giving it as his opinion that the case is antagonistic to Flourens's theory :

"However that may be, it remains certain that this girl lived without a cerebellum, posterior peduncles, or cerebral protuberance—and that she probably would have continued to live if an abdominal affection had not put an end to her days ; that she nevertheless enjoyed the faculties of sight, touch, and hearing ; that, if her intelligence was only slightly developed, there was not a complete absence of ideas ; and that, though there was paraplegia, this had always been incomplete, for the sensibility had never been diminished."

Magendie, in his comments on the case, after minutely examining the brain, gives it as his decided opinion that the absence of the cerebellum was congenital.

M. Combette refers to two other cases, in one of which there was a large tumor in the left lobe of the cerebellum, and in the other an abscess in the same position, in neither of which was there any difficulty of locomotion.

M. Lallemand¹ cites the case of the vicar of Gézeville, aged forty-six years, who for a year had experienced attacks of vertigo and vomiting, without fever. He staggered in walking, and often fell forward. On examining his brain after death, the membranes of the cerebellum were found to be depressed and shrivelled, and to contain only a little brown and fetid lymphatic purulent liquid.

Andral² states that, of ninety-three cases of cerebellar disease which he has studied, only one appeared to support the theory which locates the coördinating power in this organ.

¹ *Recherches Anatomico-pathologiques sur l'Encéphale*, etc. Paris, 1824.

² *Clinique Médicale*, seconde édition, t. v., p. 725.

On the 27th of February, 1836, M. Bouvier¹ communicated to the Académie de Médecine the particulars of the case of a man who, for a length of time, had been subject to a discharge from the ear, with deafness and frequent headache. He was suddenly seized with an attack of very severe headache, vomiting, and disorder of mind. Three weeks afterward he entered the Hôtel Dieu. He was then suffering from fixed pain in the head, obtuseness of sensibility, somnolency, vomiting, etc. The movements of all the limbs were preserved. A week subsequently he died. *Post-mortem* examination revealed, as had been foretold, the existence of caries of the temporal bone. But there was also found an abscess involving the two outer thirds of the left hemisphere of the cerebellum; the walls of this cavity, which contained several tablespoonfuls of pus, were softened.

As M. Bouvier remarks, a circumstance of great interest connected with this case is the entire absence during life of any symptoms indicating an augmented sensibility, loss of equilibrium, or excitation of the genital organs. Passing over a number of other cases which could be cited, I desire to relate briefly the particulars of two which came under my own notice.

In 1851, a Mexican shepherd was attacked near Cebolleta, in New Mexico, by Navajo Indians. He managed to escape, but in fleeing from his enemies received an arrow-wound in the posterior part of the head. He was on horseback, and, though stunned by the blow, maintained his seat in the saddle. So firmly was the arrow implanted that the shaft became detached by his efforts to remove it, leaving the head of the weapon in the skull. I saw him about two hours

¹ American Medical Intelligencer, April 1839.

subsequently. He was then in full possession of his senses and was suffering no pain. There were, however, constant vertigo and nausea, together with a sensation, as he described it, as if his head were balanced on a very delicate point, and the least inclination to one side or the other would cause it to fall off. On examining the wound, I found the arrow-head still sticking in the bone, and I had to use considerable force before I could remove it. It had entered to the extent of an inch and a half—a little below and to the left of the occipital protuberance—wounding the left lobe of the cerebellum. The vertigo continued all that night, but the nausea and vomiting stopped in the course of a few hours.

The next day he attempted to walk, but was obliged to desist on account of the vertigo. "He felt," he said, "as if he were drunk," and he staggered just like a drunken man. This feeling of vertigo continued for several weeks, lasting all through the period of suppuration. Gradually it disappeared, though, even after the lapse of a year, he felt giddy on making any unusual physical exertion. At no time was there any difficulty in coördinating the muscles of the upper or lower extremities. The latter were simply affected through the vertiginous sensation. The sensibility was unaffected throughout the whole progress of the case.

The other case was that of a man who, for several months, had suffered with vertigo, occasional convulsions, attacks of nausea, and vomiting, and a constant and violent pain affecting the back of the head. These symptoms had come on subsequently to a severe blow which he had received on the back of the head, in consequence of raising himself too soon while the horse he was riding was passing under a low archway.

When this man attempted to walk he reeled and

staggered as if he were drunk, but his movements were very different from those which we now recognize as characterizing locomotor ataxia. The upper extremities and the organs of speech were not affected; he had the entire control of his legs when lying down, and there was no diminution of sensibility anywhere. At last he became paraplegic, and shortly afterward died in a convulsion. The *post-mortem* examination showed the existence of an abscess, which had obliterated nearly the whole of the left lobe of the cerebellum.

Four cases are now under my charge in which I have reason to suspect the existence of cerebellar disease. In one of these—that of a gentleman of this city—there is intense pain in the occiput, almost constant vertigo, and slight hemiplegia. When he attempts to walk, his gait is staggering, but he lifts his feet in perfect coördination, and can stand alone, with his eyes shut and his heels close together. He can place either foot, without any difficulty, on any particular spot on a chair, and can carry a glass full of water to his lips without spilling a drop or looking at it. He has no derangement of the coördinating faculty in any part of his body, but complains of constant vertigo, which is manifestly increased whenever he attempts to walk. The sensibility is intact.

In another case, that of a gentleman from the West, similar symptoms exist. There is intense occipital pain, slight hemiplegia, confined to the right leg, vertigo, and attacks of nausea and vomiting. The giddiness is so constant that he has it even in his sleep, and is often waked by the disagreeable feeling it causes. He coördinates perfectly, but cannot walk without the support of a cane, owing to the vertigo.

There is no disturbance of sensibility. This gentleman puts on his stockings and boots without assistance; can place the big toe of either foot on any point of a chair; can carry a glass full of water to his mouth; can write, and even thread a needle,—and yet in the street he is often taken for a drunken man. I need not say that the performance of the above-mentioned acts would be utterly impossible to a person affected with locomotor ataxia.

The other two cases have very recently come under my notice. One of them is that of a gentleman occupying a prominent position, who has almost constant pain in the back of his head, and vertigo, from which he has suffered about two years. In the beginning he had, in all probability, an extravasation of blood into the left lobe of the cerebellum, for he has a slight hemiplegia of the right side, and the pain is located on the left side. He informs me that the vertigo is often so great that he cannot walk without falling; he staggers now with every step, but yet coördinates perfectly. In this case there have been no erections for a year and a half.

The other case is that of a married woman, 45 years of age, sent to me a day or two ago by my friend Dr. Woolsey Johnson, and who is afflicted with the most extreme and constant desire for sexual intercourse. So great is this impulse, that she has been in the habit of practising masturbation as many as twenty times a day. She has a severe pain in the occiput, and almost continued vertigo; there is slight paralysis of the left arm. When she walks, her gait is staggering, and she says that every thing in the room looks as though it were in motion. There are no indications of any irritation about the vagina. She

informs me that the intensity of the pain and the desire for sexual intercourse are in direct relation to each other. She coördinates all her muscles perfectly well.

In the *New York Medical Journal* for June, 1867, I detailed, under the head of Convulsive Tremor, the particulars of several cases which I thought consisted in functional cerebellar disease. In each of these there was pain in the occiput, vertigo, and an uncontrollable tremor, which came on in paroxysms.

Derangement of locomotion does, therefore, result from injury or disease of the cerebellum. Experimental physiology, as well as pathology, proves this. Beyond a doubt, the disorder is, however, clearly due to vertigo. There are, moreover, headache, vomitings, and eventually, in some cases, hemiplegia, generally of the opposite side to that of the cerebellar lesion, a fact at variance with Larrey's assertion. The gait of a person thus affected is exactly similar to that of a drunken man. As Carre¹ says, the movements are not abrupt, jerking, and exaggerated, as they are in locomotor ataxia. They are more uncertain, and do not depend upon any defect of coördination, but upon weakness of the voluntary power.

When either of the peduncles of the cerebellum is affected there is an irresistible impulse to go sideways, and sometimes gyratory movements are produced.

The researches of M. Bouillaud,² of MM. Leven and Olivier,³ and of M. Duchenne, are absolutely conclusive on this point.

¹ Nouvelles Recherches sur l'Ataxie Locomotrice Progressive, etc. Paris, 1865, p. 270.

² Union Médicale, t. ii., 1859.

³ Archives Générales, 1862-1863.

5. *In those diseases, of which the chief phenomena relate to derangement of the coördinating power, the lesion is not in the cerebellum, and the symptoms are altogether different from those due to cerebellar disease or injury.*

The affection known as locomotor ataxia is chiefly manifested by incoördination. If the cerebellum were the seat of the coördinating power, we should expect to find the lesion in this organ. Such, however, is not the case. A few cases of so-called locomotor ataxia have been reported, in which it was said the cerebellum was found diseased; but careful examination shows that these were cases of cerebellar disease attended with vertigo. In true locomotor ataxia the lesion is always found in the posterior columns of the spinal cord, or in the posterior roots of the spinal nerves.

Moreover, in the ataxic form of aphasia, in which the patient can write, can move the tongue and lips in all possible directions, and yet is unable to so coördinate the muscles of speech as to enunciate words, the lesion is not found in the cerebellum, but in the posterior part of the third convolution of the anterior lobe of the left cerebral hemisphere.

Relative to the symptoms which seem to distinguish cerebellar disease from locomotor ataxia, the line is well defined. The chief difficulty has been, that authors have failed to distinguish between the effects of vertigo and the consequences of a loss of the coördinating power. Flourens himself, as we have seen, made this mistake, and Dr. Todd and others have repeated it. Thus Dr. Todd¹ says: "Animals deprived of the cerebellum are in a condition very similar to that of a drunken man, so far as relates to

¹ Cyclopædia of Anatomy and Physiology, vol. iii.

their power of locomotion. They are unable to produce that combination of action in different sets of muscles which is necessary to enable them to assume or maintain any attitudes."¹ Now, the first sentence is true of cerebellar disease, but not of locomotor ataxia, of which disease vertigo is not a symptom, neither is the gait of an ataxic patient at all like that of a drunken man. The second sentence is true of persons suffering from locomotor ataxia, but is not true of those who have a lesion of the cerebellum, and who are able to coördinate perfectly well.

In lesions of the cerebellum the cutaneous sensibility remains unimpaired; in locomotor ataxia, on the contrary, it is always affected.

Duchenne, who at one time held the opinion that locomotor ataxia was a disease, the seat of which was in the cerebellum, has lately recanted, and now contends that there is no relation between them. He brings forward several cases which are conclusive as to this point.

I have thus endeavored to clear up several important points relative to the physiology and pathology of the cerebellum. In the course of my inquiry I have performed a great many experiments upon different animals, and have thus arrived at what I think is a correct view of the physiology of the organ in question. We have seen that it has no special and exclusive control over the sexual appetite, and no particular function to perform in connection with coördination. My opinion is, that it has no special or exclusive function of any kind, but that it is simply an additional generator of nervous power, a ganglion to be added

¹ Diagnostic Differential des Affections Cérébelleuses et de l'Ataxie Locomotrice Progressive.—*Gazette Hebdomadaire*, 1866.

to the cerebrum, and performing analogous offices in the economy. I advance this theory not without hesitation ; but, so far as my observation extends, both experimental physiology and pathology appear to unite in establishing its correctness. If I do not now adduce the proofs in detail, it is because I am fearful of having already wearied you with a subject which, though interesting and important, both in its purely scientific and practical relations, I am conscious of having very imperfectly brought to your attention.



